ITS Publications and Presentations in FY 2006

NTIA Publications

M. Cotton, R. Achatz, J. Wepman, and R. Dalke, "Interference potential of ultrawideband signals – Part 3: Measurement of ultrawideband interference to C-band satellite digital television receivers," NTIA Report TR-06-437, Feb. 2006.

> This report provides results from tests that measured digital television (DTV) susceptibility to ultrawideband (UWB) interference. A test system was developed to inject interference with known characteristics into a victim receiver and quantitatively measure susceptibility. In this experiment, a C-band satellite DTV victim receiver was injected with Dithered-Pulse (DP), Direct-Sequence (DS), and Multi-Band OFDM (MB) UWB interference. Results showed that the UWB signals could be categorized into three signal sets of common DTV susceptibility behavior. Interestingly, the categorized signals, band-limited by the DTV receiver filter, also had common characteristics. Set 1 consists of signals whose DTV susceptibility and band-limited signal characteristics resemble Gaussian noise. Set 2 consists of signals more deleterious than Gaussian noise interference. Notably, these signals had a wide range of band-limited signal characteristics and susceptibilities. Set 3 consists of a signal that is relatively benign. Results also showed that measurable band-limited characteristics, e.g., burst duration (BD), burst interval (BI), fractional on-time (ζDTV), and peak-to-average ratio (P/A), of the interfering signal are useful for predicting susceptibility. Finally, it was determined that continuous and gated noise signals can be used to emulate the interference effects of DS and MB signals for the DTV victim receiver and operational scenarios tested in this study. This might not be true, however, for testing the susceptibility of other victim receivers operating in narrower bandwidths as indicated by amplitude probability distributions as a function of frequency for MB signals band-limited to relatively narrow bandwidths.

M. McFarland, M.H. Pinson, and S. Wolf, "Batch video quality metric (BVQM) user's manual," NTIA Handbook HB-06-441, Sep. 2006.

> This handbook provides a user's manual for the batch video quality metric (BVQM) tool. BVQM runs under the Windows XP® operating system. BVQM performs objective automated quality assessments of processed video clip batches (i.e., as output by a video system under test). BVQM reports video calibration and quality metric results such as: temporal registration, spatial registration, spatial scaling, valid region, gain/level offset, and objective video quality estimates. BVQM operates on original and processed video files only, and has no video capture capability.
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> BVQM compares the original video clip to the processed video clip and reports quality estimates on a scale from zero to one. On this scale, zero means that no impairment is visible and one means that the video clip has reached the maximum impairment level (excursions beyond one are possible for extremely impaired video sequences).

M. McFarland, M.H. Pinson, and S. Wolf, "BVQM software," NTIA Software & Data Product SD-06-443, Aug. 2006.

M.H. Pinson and S. Wolf, "CVQM software," NTIA Software & Data Product SD-06-442a, Jul. 2006 (revision of SD-06-442, Nov. 2005).

M.H. Pinson and S. Wolf, "In-service video quality metric (IVQM) user's manual," NTIA Handbook HB-06-434a, Jul. 2006 (revision of HB-06-434, Dec. 2005, and HB-05-424, Apr. 2005).

> The purpose of this handbook is to provide a user's manual for the in-service video quality metric (IVQM) tool. IVQM performs automated processing of live video signals. This program runs under the Windows XP® operating system on two PCs communicating through an IP connection. IVQM performs image acquisition, temporal registration, other video calibration (spatial registration, spatial scaling, valid region, and gain/level offset), and video quality estimation.

IVQM compares the source video sequence to the destination video sequence (i.e., as output by the video system under test). Each program alternates between video capture and video analysis. Every source/destination video sequence pair is processed through three main steps. First, the sequences are buffered onto a hard drive. Second, the sequences are temporally registered. Third, the video quality of the destination video sequence is estimated. Quality estimates are reported on a scale of zero to one, where zero means that no impairment is visible and one means that the video clip has reached the maximum impairment level. Some video sequences may also be used to estimate other calibration values (spatial registration, spatial scaling, valid region estimation, and gain/level offset). The user has control over how often these other calibration values are calculated.

M.H. Pinson and S. Wolf, "IVQM software," NTIA Software & Data Product SD-06-435a, Jul. 2006 (revision of SD-06-435, Nov. 2005, and SD-05-425, Apr. 2005).

M.H. Pinson and S. Wolf, "Reduced reference video calibration algorithms," NTIA Report TR-06-433a, Jul. 2006 (revision of TR-06-433, Oct. 2005).

This report describes four Reduced Reference (RR) video calibration algorithms of low computational complexity. RR methods are useful for performing end-to-end in-service video quality measurements since these methods utilize a low bandwidth network connection between the original (source) and processed (destination) ends. The first RR video calibration algorithm computes temporal registration of the processed video stream with respect to the original video stream (i.e., video delay estimation). The second algorithm jointly calculates spatial scaling and spatial shift. The third algorithm calculates luminance gain level offset of the processed video stream with respect to the original video stream. The fourth algorithm estimates the valid video region of the original or processed video stream (i.e., the portion of the video image that contains actual picture content). All the algorithms utilize only the luminance (Y) image plane of the video signal.

P.J. Raush and K.E. Novik (Eds.), "Proceedings of the International Symposium on Advanced Radio Technologies, March 7-9, 2006," NTIA Special Publication SP-06-438, Mar. 2006.

No abstract available.

F.H. Sanders and B.J. Ramsey, "Phased array antenna pattern variation with frequency and implications for radar spectrum measurements," NTIA Report TR-06-436, Dec. 2005.

Measured antenna patterns of an end-fed slotted waveguide antenna and a phased-array patch antenna used in maritime radionavigation radars across the frequency range 8500-10800 MHz are presented along with a measurement technique that characterizes the antenna patterns as a function of frequency. The frequency-dependent variation in the measured pattern of the slotted waveguide is compared to the frequency dependence of an ideal pattern based on the slot geometry. The implications for radar emissions measurement techniques are discussed.

F.H. Sanders, J.R. Hoffman, and Y. Lo, "Resolving interference from an airport surveillance radar to a weather radar," NTIA Technical Memorandum TM-06-439, Apr. 2006.

In response to interference from an S-band (2700-2900 MHz) airport surveillance radar (ASR) to a meteorological (weather) radar in the same band, measurements were performed at the field location of the two radars to determine the interference mechanism and any possible mitigation options. Measurements included emission spectra of the ASR and observations of the interference energy in the RF front-end and IF stages of the weather radar. Measurement results showed that interference energy originated in the unwanted emissions of the ASR (i.e., front-end overload was not occurring in the weather radar). But the problem was exacerbated by the placement of a passive diode limiter ahead of a bandpass filter in the weather radar receiver's RF front-end. The interference could not be mitigated unless the front-end configuration of the weather radar was modified. With the necessary modification completed, the interference was successfully mitigated by installing a conventional notch filter on the ASR's output stage, the notch being tuned to the weather radar frequency. It is recommended that the front-end configuration of all weather radars of the type in

question should be immediately changed in the same way as the weather radar in this study, and that appropriate output filters should be installed in ASRs that are located in close proximity to these weather radars to mitigate interference effects at all sites in the U.S.

F.H. Sanders, R.L. Sole, B.L. Bedford, D. Franc, and T. Pawlowitz, "Effects of RF interference on radar receivers," NTIA Report TR-06-444, Sep. 2006.

This report describes the results of interference tests and measurements that have been performed on radar receivers that have various missions in several spectrum bands. Radar target losses have been measured under controlled conditions in the presence of radio frequency (RF) interference. Radar types that have been examined include short range and long range air traffic control; weather surveillance; and maritime navigation and surface search. Radar receivers experience loss of desired targets when interference from high duty cycle (more than about 1-3%) communication-type signals is as low as -10 dB to -6 dB relative to radar receiver inherent noise levels. Conversely, radars perform robustly in the presence of low duty cycle (less than 1-3%) signals such as those emitted by other radars. Target losses at low levels are insidious because they do not cause overt indications such as strobes on displays. Therefore operators are usually unaware that they are losing targets due to low-level interference. Interference can cause the loss of targets at any range. Low interference thresholds for communication-type signals, insidious behavior of target losses, and potential loss of targets at any range all combine to make low-level interference to radar receivers a very serious problem.

Outside Publications

Articles in Conference Proceedings

D.J. Atkinson, "Public safety environmental noise challenges for land mobile radio vocoders," in "Proceedings of the International Symposium on Advanced Radio Technologies: March 7-9, 2006," P.J. Raush and K.E. Novik, Eds., NTIA Special Publication SP-06-438, Mar. 2006, pp. 71-78.

This paper investigates the effect on vocoders of background noise that exists in environments where public safety officials and first responders need to communicate. Four different environments were examined: police cruiser, fire engine, rescue boat, and rescue helicopter. During the examination, noise levels were measured, as well as speech levels of actual practitioners working in that environment. Based on those results a controlled laboratory experiment was conducted to determine the effectiveness of vocoders used in communications equipment subjected to those environments. The experimental conclusion is that while digital vocoders do not perform as well as analog transmission in the presence of high levels of background noise, moderate amounts of noise cancellation prior to the signal injection into the vocoder can somewhat mitigate those detrimental effects.

C. Ford and A. Webster, "Introduction to objective multimedia quality assessment models," in "Proceedings of the International Symposium on Advanced Radio Technologies: March 7-9, 2006," P.J. Raush and K.E. Novik, Eds., NTIA Special Publication SP-06-438, Mar. 2006, pp. 8-14.

The transmission of multimedia signals over wireless channels has increased exponentially in the past decade. The widespread use of digital technology for the transmission of audio and video signals has led to the need for objective quality assessment methods based on human perception. In particular, the distribution of multimedia signals over wireless links to devices such as laptops, PDAs, and cell phones is widespread. Manufacturers can use objective models to improve products and analyze deployment. Service providers can use objective models to monitor the quality of service they provide. This paper is an introduction to the concepts of multimedia quality assessment models and the design of subjective tests for objective model validation.

J. Kub and E. Nelson, "Extensible software for automated testing of public safety P25 land mobile radios," in "Proceedings of the International Symposium on Advanced Radio Technologies: March 7-9, 2006," P.J. Raush and K.E. Novik, Eds., NTIA Special Publication SP-06-438, Mar. 2006, pp. 92-97.

One of the most prominent digital Land Mobile Radio (LMR) technologies used by public

safety agencies, Project 25, is built upon an expansive suit of standards defining numerous open interfaces. As the P25 standard has matured and greater numbers of subscriber units and fixed station equipment have reached the market, increasing complaints of non-interoperability and substandard performance have arisen. In response, P25 users and manufacturers are forming a P25 Compliance Assessment Program. One element of this program requires electrical performance measurements on P25 portable and mobile radios. These tests will be conducted using an automated test software application developed at the Institute for Telecommunication Sciences. This paper describes background information on the compliance program, discusses the technical approaches taken in application development, and provides a detailed overview of the test application's functionality and capabilities.

F. Sanders, J. Wepman, and S. Engelking, "Development of performance testing methods for dynamic frequency selection (DFS) 5-GHz wireless access systems (WAS)," in "Proceedings of the International Symposium on Advanced Radio Technologies: March 7-9, 2006," P.J. Raush and K.E. Novik, Eds., NTIA Special Publication SP-06-438, Mar. 2006, pp. 39-48.

Dynamic frequency selection (DFS) is an agile radio technology designed to allow wireless access systems (WAS) to operate in 5-GHz spectrum bands that are allocated on a primary basis to radiolocation systems (radars) without causing interference to radar operations. DFS is designed to accomplish this feat by detecting co-channel radar emissions and then avoiding or vacating any locally occupied radar frequencies. DFS technology thus promises to provide more radio spectrum for applications including multimedia transmission without denying use of that spectrum to existing users. Because the successful deployment of 5-GHz DFS technology in commercially available WAS devices depends critically on the ability of testing labs to verify that such products can detect co-channel radar emissions and vacate those channels, the development of adequate performance verification methods has been critical to the development of DFS technology as a whole. This paper summarizes the history of DFS spectrum allocation by the International Telecommunication Union (ITU), the specification of DFS performance parameters in a seminal ITU Recommendation, and the development in the United States of DFS performance verification test methods that can be applied to commercially produced DFS WAS products. That development has been carried out primarily by the U.S. Department of Commerce National Telecommunications and Information Administration Office of Spectrum Management and the NTIA Institute for Telecommunication Sciences, working in close coordination with other Federal agencies (including the Federal Communications Commission) and U.S. industry.

S.D. Voran, "Listening-time relationships in a subjective speech quality experiment," in *Proc. of the 5th International Conference on Measurement of Speech and Audio Quality in Networks (MESAQIN)*, Prague, Czech Republic, Jun. 2006.

We have designed, conducted, and analyzed a subjective speech quality experiment with unrestricted timing where subjects can vote whenever their opinions are fully formed, rather than at fixed time intervals. Analysis of the resulting listening times reveals that subjects tend to listen for a longer time before approving a recording and for a shorter time before rejecting a recording. This listening-time difference tends to increase for poorer quality systems and for more critical subjects. We present a mathematical model that reproduces these results. In addition, subjects operate more quickly as they move through the experiment.

S.D. Voran, "Reducing quantization errors by matching pseudoerror statistics," in *Proc. of IEEE Digital Signal Processing Workshop*, Grand Teton National Park, Wyoming, Sep. 2006.

We investigate the use of an adaptive processor (a quantizer pseudoinverse) and the statistics of the associated pseudoerror signal to reduce quantization error in scalar quantizers when a small amount of prior knowledge about the signal x is available. This approach uses both the quantizer representation points and the thresholds at the receiver. No increase in the transmitted data rate is required. We discuss examples that use low-pass, high-pass, and band-pass signals along with an adaptive processor that consists of a set of filters and clippers. Matching a single pseudoerror statistic to a target value is sufficient to attain modest reductions in

quantization error in situations with one degree of freedom. Adaptive processing based on a pair of pseudoerror statistics allows for quantization noise reduction in problems with two degrees of freedom.

Journal Articles

R.J. Matheson, "Principles of flexible-use spectrum rights," *Journal of Communications and Networks*, vol. 8, no. 2, Jun. 2006, pp. 144-150.

A serious problem with traditional "command & control" spectrum management techniques is that they do not easily accommodate new technologies and new services. This paper describes the necessary principles of flexible-use spectrum rights which may allow a wide variety of spectrum uses in a single general-purpose band. Based on the electrospace description of the radio spectrum, these principles allow general aggregation or division of licensed electrospace regions via secondary markets, providing rules for how regulatory limits change under aggregation or division. These flexible-use principles limit transmitter behaviors that tend to create a more difficult operating environment for receivers, while making receivers responsible for handling any remaining interference. The author shows how flexible-use principles could provide a basis for real-world flexible-use frequency bands.

K. Tilley, "Major telecommunications institute seeks volunteers to help with testing the performance of first-responder video," *Evidence Technology Magazine*, Jul.-Aug. 2006, p. 10.

No abstract available.

Unpublished Presentations

K. Allen, "Software radio and spectral efficiency," talk given at the Institute for Defense and Government Advancement's 2006 Software Radio Summit, Feb. 2006.

R. DeBolt, "Developing a Geographic Information System (GIS) based propagation tool," talk and demonstration given at ESRI International User Conference, San Diego, California, Aug. 6, 2006.

N. DeMinco, "Analysis of mutual coupling of antennas on a 47-foot Coast Guard boat," International Union of Radio Science (URSI) Meeting, Boulder, Colorado, Jan. 7, 2006.

R. Matheson, class on spectrum measurements and monitoring, presented for the United States Telecommunications Training Institute (USTTI) Mar. 2006.

R. Matheson, "Modern spectrum management alternatives," guest lecture given to class on Spectrum Management, University of Colorado Interdisciplinary Telecommunications Program, Jun. 29, 2006.

P. McKenna, "Propagation prediction models and techniques," guest lecture given to class on Spectrum Management, University of Colorado Interdisciplinary Telecommunications Program, Jun. 20, 2006.

E. Nelson, "Managing intersystem interference between analog and digital two-way radio systems," International Wireless Communications Expo (IWCE), Las Vegas, Nevada, May 2005.

S. Wolf, M.H. Pinson, and S.D. Voran, "Objective measurement of user-perceived audio and video quality," Tutorial given at ISART 2006, Mar. 7, 2006.

Conferences Sponsored by ITS

International Symposium on Advanced Radio Technologies (ISART 2006)

The International Symposium on Advanced Radio Technologies (ISART 2006) was held March 7-9, 2006, in Boulder. This symposium explores the current state of the radio art with an eye towards forecasting the use of wireless technology in the future. The theme for ISART 2006 was "The Future of Multimedia Communications." The keynote, "The Role of the Regulator in Fostering Innovation," was given by Christopher Haslett of Ofcom, UK. The proceedings were printed as NTIA Special Publication SP-06-438. ISART brings together a diverse collection of people from academia, business, and government agencies to discuss the interplay between technological "how-to," the possibilities and restrictions created by regulation and policy, and the economic motivation of the business world. For more information about ISART, see: http://www.its.bldrdoc.gov/isart/.